SSPC 62 - ALTERNATIVE VENTILATION RATE (AVR) CALCULATIONS: WHAT IS BEING PROPOSED

1. Minimum Ventilation Rates (MVR)

- These are listed in Table 5.2.
- They do not appear to be very different from those in Std. 62-89.
- Primary differences from 62-89 are that source control is stated as being the preferred control method and that no-smoking is assumed to be the baseline condition.
- Air exchange effectiveness assumes perfect mixing. Increases in ventilation rates are required for less than perfect mixing.
- Smoking ventilation rate is stated as being 120 m^3/cigarette. This is specifically not for health concerns. It is not stated if this is in addition to the MVR given in Table 5.2 or instead of the MVR in Table 5.2.

2. Table 5.3 - Maximum Source Strengths

Contaminant	Source Strength Calculation	Resulting Source Strength (mg/m^2-hr)
Carbon Monoxide	0.36 X OAR X OCC	25.2
Formaldehyde	0.0036 X OAR X OCC	0.25
Lead	0.000054 X OAR X OCC	0.0038
Nitrogen Dioxide	0.0036 X OAR X OCC	0.25
Ozone	0.0036 X OAR X OCC	0.25
PM_{10}	0.0018 X OAR X OCC	0.13
Radon	1.3 X OAR X OCC	91 (bq/m^2-hr)
Sulfur Dioxide	0.0029 X OAR X OCC	0.20
TVOC (C = 300 $\mu g/m^3$)	0.01 X OAR X OCC	0.7
(C = 1000 $\mu g/m^3$)	0.036 X OAR X OCC	2.5
(C = 3000 $\mu g/m^3$)	0.1 X OAR X OCC	7

Where: OAR = MVR in l/s-p (assumed 10)
OCC = occupancy in p/100 m^2 (assume 7)

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These source strengths can be compared against those given in table H-1 to determine if the MVR will be acceptable for a given source or combination of sources.

The acceptable indoor concentrations that these source strengths are based on are taken from Table C-1a.

3. Section 5.3 - Alternate Ventilation Rates (AVR)

AVR = [ER/(C-Co)] - CRA

Where:

ER = The sum of all sources of a contaminant (Table H-1)

C = The guideline indoor concentration (Table C-1a)

Co = The outdoor (make-up) air concentration

CRA = Cleaned, recirculated air

When units of AVR and CRA are l/s-m^2, ER = mg/hr-m^2, C and Co = $\mu g/m^3$ then the equation becomes:

AVR (l/s-m^2) = 278 x [ER/(C-Co)] - CRA

Where:

278 = Coefficient for conversion of units

This is to be used in circumstances where there are expected high emission sources that will not be handled by the MVR.

Comments - The allowable ER for a given AVR will become smaller as Co approaches C. If Co = C then no indoor sources will be allowed. If Co = 0 then the acceptable total ER will be that calculated in Table 5.3.

CRA can be used to increase the allowable ER (or decrease the calculated AVR) but assumed efficiency for mixing appears to be 1.0. For a given ER and calculated AVR, resulting indoor air concentrations will exceed C by the amount of mixing inefficiency.

4. Section 5.3 - Procedures for determining AVR Bjarne Olesen

- Sum all of the sources for one contaminant (e.g., TVOC).
- Calculate AVR for all expected contaminants and sources.

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The required AVR will be the largest calculated.

- For health based indoor air criteria, use table C-1a or Tables C-1 through C-4.
- Emission rates are to be obtained from the manufacturer or taken from table H-1.
- For comfort based indoor air criteria, odor sources are given in Tables 5.5 through 5.7. Strengths are given in CO_2 equivalent (assumed to be determined by the number of people generating this amount of CO_2). Adaptation is assumed to not occur for irritants (e.g., ETS).
- The example table shows values not very different from those in Std. 62-89. This is particularly true when one considers the lack of precision in these types of calculations.

5. Art Wheeler's 6/9/94 memo re: Rational Vent. Rate Task Group

- This memo proposes table 5.2 ventilation rates. These are determined by combining required ventilation rates for people, building and process sources. Three methods of combining ventilation rates are shown: 1. Add all rates; 2. Choose the highest rate; 3. Perform a regression analysis. The required ventilation rates for people and buildings appear to be selected by Fanger in his 9/6/94 memo to the task group with some juggling for adapted vs. unadapted persons and analyses of building surface areas.
- TVOC emission rates are taken from Table H-1; carpet, wall coverings & furniture - 0.3 mg/m^2-hr (carpet - 0.15, wall covering - 0.1; furniture - 0.05). The wall covering and furniture source strengths do not correspond to Table H-1
- For smoking 60 l/s/smoker (30 cfm/p at 25% smokers) is to be added to the determined ventilation rate (taken from Table 2 of the European Standard).
- Wheeler appears quite liberal in his requirements regarding CRA for gaseous contaminants. He states (pg. 4) "For gaseous contaminants, recirculated air may be considered equivalent to

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outdoor air, unless unusual sources exist..." This is in contrast to his proposed requirement for particulates which requires filtration.

COMPARISON VENTILATION RATES FOR VARIOUS ENVIRONMENTS

Environment	Ventilation Rate (l/s/p)			
	Wheeler	Fanger	Olesen	Table 5.2
Office	11.7, 7.2, 7.9	14.5, 10	14.3, 8.6	10
Conf. Room	7, 5, 5.2			10
Classroom	4.5, 2.5, 2.8	8.0, 3.5	12, 5	8
Auditorium	2.9, 2.5, 3	7.3, 2.8	8.6, 3.1	8

6. Table H-1 - Default Emission Rates

- This table provides eight example sources: flooring, carpet, wall coverings, painted surfaces, furniture, office machines, smoking and space heaters.
- Except for office machines, smoking and space heaters, the only substances for which source strengths are given are TVOC and formaldehyde.
- It is not known if sources are for new or aged materials.
- Emission rates in this table do not appear to be based on much literature background.

Over-all conclusions:

Required ventilation rates appear to be determined by two different methods: comfort concerns and health concerns.

Comfort - If no "strong" sources are expected, use values in Table 5.2. There appear to be at least four versions of potential values for this table. They seem to be based on odor (Fanger) or CO_2 equivalents (Olesen). The big difference in proposed values seems to come when adapted persons are used. This drives suggested ventilation rates down near the Std. 62-73 levels. Otherwise, most ventilation rates do not appear to differ significantly from Std. 62-89.

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Health - If "strong" sources are expected, then the AVR must be calculated. This is dependent on the expected source strength of a given contaminant from all expected sources and the acceptable level of that contaminant. This must be calculated for all expected contaminants and the one generating the highest AVR used.

Source strengths are to be obtained from the manufacturer or Table H-1. Sources in Table H-1 are primarily for TVOC and formaldehyde. For most examples, it is not known if the materials are aged or not. The emission rates appear to be taken from a relatively narrow range of literature sources. It is not known how representative they are of the "universe" of emission rates being tested.

Acceptable concentrations of some contaminants come from Table C-1a. Guidance regarding other substances can be obtained from Tables C-1 through C-4. These tables give highly variable values. For most, if not all, individual VOC's the concentrations given in these tables far exceed the criteria values for TVOC in Table C-1a. Concentrations in Table C-1a appear to be much lower than what would be necessary for the protection of comfort and health concerns.

Due to the few sources and substances given in Table H-1 it is expected that AVR can be calculated for only a small subset of possible situations.

Smoking - Smoking is handled in three different manners: 1. Wheeler; 2. Section 5.22; 3. AVR method.

1. Wheeler suggests 60 l/s-smoker additional ventilation. At 25% smokers this equals 15 l/s-p extra ventilation needed in any given environment.

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2. Section 5.22 requires 120 m^3 (120,000 l) outdoor air per cigarette. At 25% smokers and 1 cigarette per hour this equals approximately 8 l/s-p (additional?) ventilation rate. (120,000 l/cig X 0.25 smokers/person X 1/3600 hr/sec)

3. AVR method

Substance	Source Strength (mg/m^2-hr) Table H-1	Table C-1a value
CO	0.09	9 ppm (10,000 $\mu g/m^3$)
HCOH	1.0	0.1 ppm (100 $\mu g/m^3$)
NO_2	0.2	100 $\mu g/m^3$ (100 $\mu g/m^3$)
PM_{10}	0.8	50 $\mu g/m^3$
TVOC	9.0	300 - 3,000 $\mu g/m^3$

AVR = 278 X ER/(C-Co) - CRA

Where:

AVR = Vent. Rate (l/s-m^2)

ER = Emission Rate (mg/m^2-hr)

C = Acceptable Conc. ($\mu g/m^3$, from Table C-1a)

Assume Co, outdoor concentration and CRA, cleaned recirculated air = 0

AVR = 278 X ER/C

For CO AVR = 278 (0.09/10,000) = 0.0025 l/s-m^2

@ 7 p/100 m^2 = **0.04 l/s-p**

For HCOH AVR = 278 (0.2/100) = 2.78 l/s-m^2

@ 7 p/100 m^2 = **39.7 l/s-p**

For NO_2 AVR = 278 (0.2/100) = 0.56 l/s-m^2

@ 7 p/100 m^2 = **7.94 l/s-p**

For PM_{10} AVR = 278 (0.8/50) = 4.45 l/s-m^2

@ 7 p/100 m^2 = **63.5 l/s-p**

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For TVOC AVR = 278 (3.3/300) = 3.06 l/s-m^2

@ 7 p/100 m^2 = **43.7 l/s-p (87.4 cfm/p)**

This does not include any other volatile organic or formaldehyde sources either indoors or outdoors. Increases in the calculated AVR will occur either due to additional sources or incomplete mixing. This is also the "typical" indoor environment with no "strong" sources that is amenable to the MVR.

Calculating Indoor Air Concentrations - If the AVR equation is solved for C then typical values for ER and AVR can be plugged in to predict resulting indoor concentrations. This can be compared with actual indoor concentrations from the literature, providing a "reality check" for the AVR method.

AVR = 278(ER/C) assuming Co & CRA = 0

C = 278(ER/AVR)

If one further assumes AVR = 10 l/s-p or 0.7 l/m^2-p (@ 7 p/100 m^2) then:

C = 397 X ER

For smoking:

Substance	ER (Table H-1)	C ($\mu g/m^3$)	Real Levels in offices and public places due to ETS (Holcomb,1993)
CO	0.09	35.7	0 ppm
HCOH	1.0	397	approx 50 $\mu g/m^{3*}$
NO_2	0.2	79.4	approx 60 - 100 $\mu g/m^{3*}$
PM_{10}	0.8	318	21.8 $\mu g/m^3$
TVOC	9.0	3,573	315.1 $\mu g/m^{3*}$

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For Offices

Substance	ER (Table H-1)	C ($\mu g/m^3$)	Real Levels in offices and public places (Holcomb,1993)
HCOH	0.73	290	approx 50 $\mu g/m^{3*}$
TVOC	3.3	1,310	315.1 $\mu g/m^{3*}$

* concentration reported includes all sources, not just ETS

These calculated indoor air concentrations (C) are the minimum which would be expected in a real life situation. They are calculated with minimum ER values (i.e., only a few sources for a given contaminant) and assumed Std. 62-89 ventilation rates. They assume perfect mixing and no outdoor sources. They are also consistently higher than average concentrations actually reported in the literature. This could be due to some combination of the following:

1. Average ventilation rates in U.S. buildings are significantly higher than those specified in Std. 62-89.

2. The AVR equation does not accurately estimate the effect of ventilation on indoor concentrations.

3. The ER values in Table H-1 are unreasonably high.

Since the first explanations is not very likely, the reason seems to be some combination of 2 & 3. Whatever the ultimate reason, the AVR equation and source strengths published in Table H-1 are not acceptable for determining required ventilation rates.

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